International Journal of Odonatology 4 (1): 57-69, 2001

Recent Odonata records from southern Florida – effects of global warming?

Dennis R. Paulson
Slater Museum of Natural History, University of Puget Sound,
Tacoma, WA 98416, USA. <dpaulson@ups.edu>

Received 27 June 2000; revised and accepted 14 November 2000.
Key words: Odonata, dragonfly, *Chrysobasis lucifer*, *Nehalennia minuta*, distribution, phenology, global warming, Florida.

Abstract

A brief Odonata survey in southern Florida, USA, in January 2000 resulted in the discovery of two new species, *Chrysobasis lucifer* and *Nehalennia minuta*, for the USA and established populations of two other species, *Tholymis citrina* and *Tramea calverti*, that had been considered vagrants. Flight seasons of six additional species were extended. These records are discussed in light of the predicted effects of global warming.

Introduction

Two hypotheses can be generated to predict the effects of global warming on Odonata species: (1) northern range limits should be extended northward, and (2) adult flight seasons should become longer. A weeklong Odonata survey in southern Florida by the author and Netta Smith in January 2000 furnished the opportunity to gather data relating to these hypotheses. This visit resulted in not only a better idea of adult odonate abundance during midwinter in southern Florida but also the discovery of a surprising number of tropical species apparently extending their ranges northward. The itinerary included three days in the Florida Keys, one day in Everglades National Park, and three days in the southwestern mainland.

Dunkle (1989, 1990, 1992) summarized the distribution and flight seasons of all species of Odonata in Florida. Paulson (1999) presented more detailed accounts of the status of Anisoptera in southern Florida through 1965. During the latter study, few Odonata were seen in January, which was considered the low point of the year for adult odonate activity. Adults of only four species (5 specimens) of Anisoptera and five species (21 specimens) of Zygoptera were examined that had been collected in that month (Paulson 1999 and unpubl.). Although Dunkle (1992) listed definite or implied January records from the state for 53 species, he provided no details about their relative abundance in January.

The following localities were surveyed, some of them only briefly:

1. Monroe Co., Stock Island, botanical garden consisting of tropical hammock and edge with woodland pond (24°34'N, 81°45'W), 7 Jan
2. Monroe Co., Stock Island, cattail-lined pond on edge of golf course (same as 1), 7 Jan
3. Monroe Co., Stock Island, sedge-filled wet depression (same as 1), 7 Jan
4. Monroe Co., Cudjoe Key, hammock edge (24°40'N, 81°30'W), 7 Jan
5. Monroe Co., Big Pine Key, Blue Hole, a permanent rockpit in pineland (24°42'N, 81°22'E), 6-7 Jan
6. Monroe Co., Big Pine Key, permanent rockpit, dried-up seasonal marsh, mangroves, and hammock edge ca 1 km SW of Blue Hole (same as 5), 6-7 Jan
7. Monroe Co., Big Pine Key, Southeast Point, mangrove/hammock edge (24°38'N, 81°20'E), 7 Jan
8. Monroe Co., No Name Key, edge of tropical hammock at dusk (24°42'N, 81°19'E), 6 Jan
9. Monroe Co., Grassy Key, mangrove/hammock edge (24°46'N, 80°56'E), 7-8 Jan
10. Monroe Co., Long Key State Park, mangroves and strand vegetation (24°49'N, 80°49'E), 6 Jan
11. Monroe Co., Everglades National Park, Eco Pond, near Flamingo, large, heavily vegetated, shallow freshwater pond for sewage treatment in coastal salt marsh (25°08'N, 80°57'E), 9 Jan
12. Dade Co., Everglades National Park, Royal Palm Ranger Station, pond and marsh, tropical hammock (25°23'N, 80°37'E), 9 Jan
13. Dade Co., Everglades National Park, park headquarters, large pond (same as 12), 8 Jan
14. Dade Co., south of Florida City, open marshes and canals (25°25'N, 80°26'E), 6, 8 Jan
15. Dade Co., US 41 through Big Cypress Swamp, cypress swamp and flats, canal (25°47'N, 80°51'E), 10 Jan
16. Collier Co., Monroe Station, flooded cypress and hardwood swamp and drying sedge flats (25°52'N, 81°06'E), 10 Jan
17. Collier Co., Burns Lake, large deep rockpit in pine/cypress/sedge flats (25°54'N, 81°14'E), 10, 12 Jan
18. Collier Co., along Fla. 841, N of Ochopee, canal and drying marsh (25°56'N, 81°19'E), 12 Jan
19. Collier Co., Copeland, canal (25°57'N, 81°21'E), 12 Jan
20. Collier Co., Fakahatchee Strand, flooded cypress swamp and flats, water with slight current at culverts (25°59'N, 81°24'E), 10, 12 Jan
21. Collier Co., ca 15 km W of Copeland, large canal in pineland (26°03'N, 81°27'E), 12 Jan
22. Collier Co., Corkscrew Swamp Sanctuary, boardwalk through cypress swamp (26°23'N, 81°37'E), 10 Jan
23. Lee Co., Sanibel Island, mangroves, scrub, and freshwater ponds (26°27'N, 82°07'E), 11 Jan
24. Glades Co., Fisheating Creek, cypress-fringed, slow-flowing sandy stream at dusk (26°56'N, 81°19'E), 11 Jan

The weather was uniformly warm, with highs in the range of 27-29°C every day, with partly cloudy to sunny conditions. Cloudiness at a few localities precluded a complete inventory, but there was at least some sunshine at almost all localities. Heavy rainfall in October (W.B. Robertson Jr. pers. comm.) had kept water levels up in the Everglades, although shallow, seasonal marshes in the Keys and Collier County were dried up. An attempt was made to obtain voucher specimens (indicated by asterisks after the locality number), but some of our observations were made in protected reserves where spontaneous collecting is not allowed, and an *ad hoc* trip of the nature of the present one did not allow the lengthy process necessary for the acquisition of collecting permits. A few species were documented by photographs (indicated by 'P' after the locality number).

A complete species list is included. All flight-season dates from the literature are from Dunkle (1992).

Species observed

COENAGRIONIDAE

Argia sedula (Hagen)

17*; one male. This is at the southern extreme of the range of this species.

Chrysobasis lucifer Donnelly

20* (10 Jan); one male in shade in herbaceous vegetation at edge of cypress swamp. Considerable effort was expended searching for more individuals, but none was found. This is a new record for Florida and the United States. Described by Donnelly (1967) from Guatemala, the species was subsequently found in Costa Rica, Belize, and Veracruz, Mexico (Paulson 1982; Boomsma & Dunkle 1996; González Soriano & Novelo Gutiérrez 1996). The great distance between southern Florida and the known distribution should prompt a search for the species in western Cuba. The single specimen had a red-orange abdomen tip in life, while *C. lucifer* from Central America has a bright yellow abdomen tip (Donnelly 1967); the three males in my collection from Costa Rica still show a yellow abdomen tip, while the Florida specimen has dried to orange-brown in the same area. Thus it is possible that this population is genetically distinct from those of Central America, and if it is a recent immigrant, it may come from a Cuban population also distinct from Central American populations.

Enallagma coecum (Hagen)

20*, 21*; common on sloughs and canals; mating.

Enallagma pollutum (Hagen)

12, 20*, 21*; common on sloughs and canals; mating.

Ischnura hastata (Say)

3*, 13, 16*, 17, 18P, 20*, 23; common throughout area in tall grasses and sedges away from water; few emerging from marshy areas.

Ischnura posita (Hagen)

20*, 22; common in cypress swamp.

Ischnura prognata (Hagen)

20*; common in cypress swamp; few emerging. Adults not previously recorded in January. Although Dunkle (1992) listed the species from Dade County, his southernmost record otherwise was Glades County, and I did not find *prognata* in numerous summer visits to the Big Cypress Swamp area in 1960-1964.

Ischnura ramburii (Selys)

1*, 2, 5*, 6, 11, 12, 13, 14P, 15, 17*, 18P, 20*, 21, 23; common throughout area at fresh and even brackish water; mating.

Nehalennia minuta (Selys)

5* (6 Jan); male at a tiny 2-meter wide sinkhole in low woodland near Blue Hole. The locality was checked several additional times, but no others were seen. This is a new record for Florida and the United States. Considering it is widespread in Middle America and the West Indies, including the Bahamas, this occurrence is not surprising. Westfall & May (1996) stated that the ninth abdominal segment of *N. minuta* is entirely blue above, and De Marmels (1984) differentiated *N. m. selysi* Kirby from Brazil on the basis of a rhomboidal black spot on top of that segment (he further noted that not all Brazilian specimens have the spot). However, the Florida specimen has such a spot, centered on the segment and occupying about half of its length. That this is not entirely aberrant is indicated by the presence of a spot of that size on a male from Yucatan, Mexico, in my collection. I have other males with smaller spots, occupying about 20-30% of the length of the segment, from San Luis Potosí, Veracruz, and Chiapas, Mexico, and Costa Rica. The majority of males in my collection (40/52, or 77%) lack these spots.

Although Dunkle (1992) does not list the closely related *N. pallidula* Calvert from the Keys, I have a female from Big Pine Key, collected at a buttonwood-bordered pond not far from Blue Hole, 14 June 1964; and five females from Lower Matecumbe Key, 14 April 1965, collected away from water and perhaps blown down from the mainland, as numerous other species not characteristic of the Keys were found at that time and place. Daigle (1997) also reported *pallidula* from Key Largo in April 1997. This is the first report of sympatry of these two species, although it remains to be seen which if either of them has breeding populations in the Keys.

AESHNIDAE

Anax junius (Drury)

1, 4*, 7P, 10, 11, 20, 23; individuals scattered in very small numbers on mainland and Keys, including a few bright males patrolling freshwater ponds. Paulson (1999) stated that the species was seen in southern Florida during some winters but not others.

Coryphaeschna viriditas Calvert

7*, 9, 10*; both sexes common in mangroves and strand vegetation. Many were flushed from trees and shrubs, but others were seen in feeding flights all during the day. The male and female collected were presumably immature, with clear, unworn wings and intact cerci on the female. Previous flight dates 19 March – 10 August.

Gynacantha nervosa (Rambur)

7, 12, 16*, 24; individuals were seen widely on the mainland and Keys, either when flushed from trails through woodland or in dusk feeding flights.

Nasiaeschna pentacantha (Rambur)

20* (10 Jan); two males flew over open sloughs, and a road kill there furnished a specimen. Previous flight dates 2 March – 28 December. The specimen has clear wings and is probably fairly young, not an old individual from the previous year.

Triacanthagyna trifida (Rambur)

1, 7, 8*, 24*; this species was present in some of the same areas as *Gynacantha nervosa* and in about the same numbers overall.

CORDULIIDAE

Epitheca sepia (Gloyd)

17* (12 Jan); males flew in sexual patrol flights between 16:30 and 17:30 h. Late-afternoon flying is typical of the species (Paulson 1973). Previous flight dates 3 March – 23 November.

Epitheca stella (Williamson)

13, 15*, 18*; individuals flew in steady flight east along US 41 and its bordering canal through cypresses east of the Collier County line in Dade County on 10 Jan. This flight occurred fairly early in the morning on a warm, sunny day, and individuals seemed to be feeding, but they kept moving east rather than remaining in one spot. The only specimen collected was a mature male. This may have been a movement comparable to the large flights coming out of the Everglades in the spring of 1961 (Paulson 1999). Another, readily distinguished from the previous species by its longer, more slender abdomen, was seen at the Everglades National Park headquarters on 8 Jan, and another was collected from a few feeding over the road N of Ochopee on 12 Jan. Previous flight dates 2 February – 25 April.

LIBELLULIDAE

Brachymesia furcata (Hagen)

1, 2*, 5, 6; a few males at each locality.

Brachymesia gravida (Calvert)

2, 11, 23; one male on Stock Island, two at Eco Pond, and two on a freshwater pond on Sanibel Island.

Celithemis eponina (Drury)

11P, 12, 13, 14, 15, 17*; scattered individuals seen throughout Everglades National Park and the Big Cypress area of Collier County. The male collected was immature, as were many of the individuals seen, but dark red mature males were observed as well.

Crocothemis servilia (Drury)

23*; a recently emerged female collected on Sanibel Island. Although considered "common at lentic habitats in the southern half of the Florida Peninsula" (Dunkle 1992), and known to fly throughout the year, the species was surprisingly scarce. It will be interesting to see how the only introduced odonate on the mainland of any continent persists from its original discovery in 1975 (Paulson 1978) and whether Davies' (1985) prediction of its potential for ecological harm will be confirmed or (hopefully) refuted.

Erythemis simplicicollis (Say)

11, 23*; few mature males at Eco Pond, immature male on Sanibel Island.

Erythemis vesiculosa (Fabricius)

9*, 10*, 11, 20; common in mangroves and hammocks on Long and Grassy keys, presumably nonbreeders, but surprisingly absent from freshwater bodies on the Lower Keys. Also common and breeding at Eco Pond, one seen in the Fakahatchee Strand, and a few on Sanibel Island. Sanibel Island, where it is common, appears to be about the northern limit of the range of the species in Florida (Paulson 1999), although Dunkle (1992) lists a record from Pinellas County, farther north on the Gulf coast. Paulson (1999) found the species as common in early winter as at any other time of year in far southern Florida, a very unusual situation. He had no records between 1 January and 26 February, but the present records narrow that gap slightly.

Erythrodiplax berenice (Drury)

Male seen in mangroves at the north end of Big Pine Key, 6 Jan. Although Dunkle (1992) lists the species as flying throughout the year, it is quite rare in midwinter. Much time was spent in its mangrove habitat in the Keys and on Sanibel Island during the present visit, with no additional sightings. During his study, Paulson (1999) did not find it between 9 December and 26 February.

Erythrodiplax minuscula (Rambur)

17*, 18*; mature and immature individuals were locally common in wet sedgy areas in Collier County.

Erythrodiplax umbrata (Linnaeus)

1*, 6*, 7, 9*, 12P, 14, 20, 21; immature individuals were common throughout the area

in open woodland and forest clearings. Single mature black males were seen in Dade and Collier counties, but none in the Keys.

Idiataphe cubensis (Scudder)

5, 6*; single males were seen at both freshwater rockpits on Big Pine Key, and another was collected at the mangrove edge near one of the rockpits.

Libellula incesta Hagen (?)

12; an immature male *Libellula* perched high on a dead twig at the edge of a clearing at Royal Palm Ranger Station on 9 Jan. Observed through binoculars for several minutes, it was certainly either this species or *L. vibrans* Fabricius, neither of which had been reported that far south. After examining immature males of both species in my collection, I feel strongly that the individual in question was *incesta*, as its thoracic pattern was very contrasty. *L. incesta* is known south to the northwest corner of Everglades National Park, while *vibrans* has been taken not much farther northwest, near Copeland (Paulson 1999). Either species would be out of season in January. Dunkle (1992) questioned records of *incesta* and *vibrans*, as well as *L. axilena* Westwood, from some southern Florida counties, as the specimens had been determined before his clarification of the identification of the three species (Dunkle 1985). However, all records in Paulson (1999) have been confirmed based on his criteria. Previous flight dates for *incesta* 21 March – 7 November, for *vibrans* 24 March – 11 October.

Libellula needhami Westfall

17*; two freshly emerged individuals at Burns Lake, 10 Jan. Previous flight dates 16 February – 1 November.

Miathyria marcella (Selys)

19; males common over a short stretch of canal at Copeland, where water lettuce (Pistia stratiotes) covered it; the water was open on both sides of this stretch and lacked Miathyria. Although Dunkle (1992) listed it as an all-year flier, Paulson (1999) considered it normally absent during midwinter. The species was common in southern Florida during the mid 1960s, when water hyacinths (*Eichhornia crassipes*) covered many of the canals. Subsequent control measures must have been very effective, as most of the canals we saw in January lacked both of these pervasive floating aquatics. This has surely had an effect on the abundance and distribution of *M. marcella*, which is largely dependent on them as breeding habitat (Paulson 1999).

Micrathyria aequalis (Hagen) (?)

6; male clearly of this genus was seen in grassy vegetation between rockpit and mangrove edge, 6 Jan. It matched *M. aequalis* in size and coloration and was surely not *M. didyma*, the other species known from Florida. *M. aequalis* has been known only from the Miami area in Florida (Dunkle 1992).

Micrathyria didyma (Selys)

1*; one male at a wooded pond. Just as *M. aequalis*, this species was known in Florida only from the Miami area (Dunkle 1992).

Orthemis ferruginea (Fabricius)

11, 14*, 23; common at Eco Pond; breeding; few seen elsewhere on mainland.

Orthemis sp.

1*, 2*, 5P, 6*, 11; widespread and common at freshwater bodies on Big Pine Key and Stock Island and also at Eco Pond on the mainland (where identified by sight). Interestingly, it was not seen away from water in the Keys at places where a variety of other anisopterans were common; this probably indicates the population consisted only of mature, breeding individuals. The specimens collected appear identical to specimens in my collection from the Cayman Islands and the Virgin Islands and must be the widespread undescribed Antillean species discussed by Donnelly (1995). Rather than a recent invasion, this species has probably been in southern Florida for a long time, but it has been confused with *O. ferruginea.* This is the first published record of its occurrence in Florida and the United States, however. Mature males were easily distinguished from *O. ferruginea* in southern Florida by their red, nonpruinose coloration, and females and immature males have a different thoracic pattern than that of *ferruginea.* Both species were common and breeding at Eco Pond, and males of both engaged in intraspecific chases, but I saw no interspecific aggression.

Pachydiplax longipennis (Burmeister)

11P, 12, 16, 17*, 19, 20*, 22; mature males widespread and scattered in wooded and some open wetlands on mainland; freshly emerged female at Burns Lake, 10 Jan. Males were common at only two places, one in the Fakahatchee Strand and one at Copeland; both were characterized by mats of water lettuce, and the abundance of males there relative to all other habitat types was striking. As the species is not known to be associated with any particular species of water plants, perhaps the vegetation carpet covering the water was the attractant. Has this species been affected by the removal of much of the water hyacinth cover from south Florida canals?

Pantala flavescens (Fabricius)

6, 7*, 11, 12, 13, 18*, 21, 23; scattered individuals everywhere on mainland and Keys, never more than one or two seen in one area. Surprisingly many were associated with parking lots, presumably because the shiny automobiles simulate the breeding habitat of small rain puddles.

Perithemis tenera (Say)

11, 21*; one male at each site.

Tholymis citrina Hagen

1*, 7; common in the botanical garden on Stock Island and one or more seen at Southeast Point on Big Pine Key. Individuals flew around, presumably foraging, and looked like small versions of *Gynacantha* and *Triacanthagyna*, but the *Tholymis* flew more often at midday than the larger species and often perched in the open when they landed, while the aeshnids were confined to dusk periods and typically went into the forest to perch. The only previous record of *T. citrina* from Florida was one

photographed in the same botanical garden on 18 April 1992 (Barber & Elia 1994). Rather than a vagrant to the United States mainland, the species is apparently present as an established population. Because of a pond in the botanical garden and several on the nearby golf course, Stock Island probably has more permanent fresh water than any other of the Florida Keys.

Tramea calverti Muttkowski

9*, 10P, 11; female photographed on Long Key and male collected on Grassy Key; probably others present among unidentified *Tramea*. Males were common at Eco Pond; the distinguishing characteristics of the species were easily seen with binoculars, and all *Tramea* with narrow wing bands there appeared to be this species. *T. calverti* was known in Florida from two specimens collected in Duval and Polk counties in October and was considered no more than a vagrant to the state (Dunkle 1992), as it is all the way north to New England, but it is clearly now established as a resident at the southern tip of Florida. On a trip to southern Florida 17-22 April 1992, Bob Barber (pers. comm.) saw numerous individuals on the Dry Tortugas and others on Stock Island and Big Pine Key. That year saw a massive invasion of the species along the Atlantic coast of the United States (Soltesz 1992). West Indian specimens in my collection differ from those from the Middle American mainland in having no suffusion of golden-brown on the wing membranes, and - not surprisingly - the specimen collected on Grassy Key matches the West Indian specimens quite well.

Tramea carolina (Linnaeus) (?)

11; a few of the many red *Tramea* flying at Eco Pond must have been this species, as they looked distinctly larger, with slightly larger basal wing patches, than the numerous *T. onusta* with which they flew.

Tramea insularis Hagen

5*, 6*, 10P; small feeding swarms were seen on Long and Big Pine keys, and pairs of this type on Big Pine Key and Stock Island were probably of *insularis*. Besides the four males collected, I looked closely at numerous others perched and in flight and failed to see any with red frons that would have indicated the presence of *T. abdominalis*.

Tramea lacerata Hagen

9; one seen over the road, 7 Jan.

Tramea onusta Hagen

4, 5, 11; present in smaller numbers than *T. insularis* in feeding swarms on the Keys, also common at Eco Pond.

Discussion

I consider it significant that this brief visit to southern Florida added two tropical species to the US fauna and found established populations of two additional tropical species that

had been considered vagrants in the state. The region has been reasonably well surveyed in the past, both during my study (Paulson 1999) and visits of other odonatologists. After my study was completed in 1965, *Erythemis plebeja* (Burmeister) was found in southern Florida in 1971, *Coryphaeschna adnexa* (Hagen) in 1980, *Micrathyria aequalis* and *M. didyma* in 1985, and *Tholymis citrina* and *Tramea calverti* in 1992 (Dunkle 1989; Barber & Elia 1994; R. Barber pers. comm.). I think I would have seen these species had they been present during my 3 years of intense field work. Furthermore, *Brachymesia herbida* (Gundlach), believed to have colonized southern Florida in the 1960s and then disappeared (Paulson 1999), was rediscovered in the Miami area in 1997 (Daigle 1997). Although all of these dates are rough estimates, because southern Florida has not been visited annually by odonatologists, all of these species are apparently represented by established populations in the region at this time. Finally, *Chrysobasis lucifer* and *Nehalennia minuta* were first discovered in the state in 2000. Thus in the last three decades, eight Neotropical species have been added to the fauna of southern Florida, and most of them probably colonized the area during that time (the *Chrysobasis* and *Nehalennia* cannot be considered "colonizers" until established populations are found). This rapid rate of colonization of southern Florida by tropical dragonfly species furnishes support for the hypothesis that the global warming presently occurring should lead to northward range extensions. This is especially true for very vagile groups such as the Odonata.

The successful introduction of the Asian *Crocothemis servilia*, first found in southern Florida in 1975 (Paulson 1978) and subsequently expanding northward (Daigle & Rutter 1984; Sprandel 1996), of course calls into question the source of the six other recently established species, as well as the two reported herein as recently observed. It seems certain that more exotic species of plants and animals have become established in southern Florida than anywhere else on the continent, and it is reasonable to ask if some of these newly appearing Odonata may be a consequence of introductions, perhaps along with aquatic plants or fishes. At least nine species of cichlid fishes, for example, had become established in southern Florida by 1979 (Lee et al. 1980).

However, there are several lines of evidence that point to a natural invasion of tropical Odonata, the most significant of which is that almost all of the species that have been discovered in southern Florida in recent years occur in Cuba and/or the Bahamas, the obvious source areas for such immigrants. If the presence of exotic Odonata species in southern Florida were a consequence of introductions, I would have predicted the occurrence of more species lacking from the West Indies. There are many species lacking from the West Indies but common in Central and South America (these regions the source of introduced cichlids and water plants) that presumably could thrive in southern Florida's wetlands, but none has been found. The exception to this is *Chrysobasis lucifer*, not known from the West Indies. It seems unlikely that this species would have come from Central America on its own, but it could easily occur in Cuba without having been detected; it is a species of forested swamps (Donnelly 1967).

Hurricane dispersal can also be considered as a source of some of these records (T.W. Donnelly pers. comm.), and in fact Hurricane Irene traveled from western Cuba to southern Florida on 19 October 1999, with winds over 128 kph. It is not impossible that small species such as *C. lucifer* and *N. minuta* could be hurricane-blown, but the

individuals we collected would have had to arrive in good condition and survive until we found them. Corbet (1999) listed 77 days as the maximum reproductive-period longevity for temperate-zone Zygoptera but indicated greater longevity for some tropical species (only the very large pseudostigmatids). However, some tropical coenagrionid damselflies, e.g. *Leptobasis vacillans*, may survive a dry season of 4-5 months in Venezuela (J. De Marmels pers. comm.), so it is at least possible that these individuals could have lived 79 (*N. minuta*) or 83 (*C. lucifer*) days from the passage of Irene to the time we discovered them. Of course, a hurricane bearing sufficient numbers of individuals to start a population (as few as one gravid, fertilized female) could have been the source of any of these species. Further field work will be necessary to confirm the presence of populations of *N. minuta* and *C. lucifer* in southern Florida.

There are numerous widespread pond-dwelling West Indian species not yet recorded from southern Florida that furnish a pool to continue the test of the northward-extension hypothesis. Likely candidates, based on occurrence in Cuba and/or the Bahamas, habitat preference, and abundance, are listed in Table 1.

Table 1. West Indian Odonata considered most likely to colonize Florida.

Lestes forficula Rambur	*Cannaphila insularis* Kirby
L. scalaris Gundlach	*Erythemis attala* (Selys)
Ischnura capreolus (Hagen)	*Erythrodiplax fervida* (Erichson)
Leptobasis vacillans Hagen	*E. justiniana* (Selys)
Telebasis dominicana (Williamson)	*Miathyria simplex* (Rambur)
T. vulnerata (Hagen)	*Micrathyria dissocians* Calvert
Anax amazili (Burmeister)	*M. hagenii* Kirby
A. concolor Brauer	*Perithemis domitia* (Drury)
Gynacantha ereagris Gundlach	*Tramea binotata* (Rambur)
Triacanthagyna septima (Selys)	

From my experience in the mid 1960s, when January was a low point in adult odonate activity (Paulson 1999), I was very surprised to find adults of 42 species of Odonata in southern Florida in January 2000. The hypothesis that extended flight seasons would be one effect of global warming is supported by the six species for which this was the case. I consider this a large number of flight-season extensions for a brief visit to a relatively well-studied region, and I presume they are consequences of an especially warm winter. In fact, not only was the winter of 1999-2000 the warmest on record in the USA, but temperatures were much above normal during five of the six most recent winters in the Southeast (National Climatic Data Center 2000), so winter conditions have been consistently favorable for odonates in southern Florida in recent years. With warmer winters, tropical species that spend the dry season as adults would have enhanced survival in southern Florida. Also, heavy rains in late fall kept water levels higher than usual for midwinter, and tropical species that breed in shallow water might have been stimulated to continue breeding later in the winter and might even have been able to produce an additional brood.

Recent northward extensions of Odonata ranges have been documented elsewhere in North America, for example *Lestes forficula* Rambur, *Erythemis plebeja* (Burmeister), *E. vesiculosa* (Fabricius), and *Micrathyria hagenii* Kirby appearing farther north along the Texas coast than they had been found previously (Behrstock 2000); a rise in both average and minimum temperatures occurred in that region over the last 25 years. Similar extensions have been reported for European dragonflies (A. Parr, J.J.A. van Dijk, K.-D. Dijkstra, and V. Kalkman pers. comm.) and in European butterflies (Parmesan et al. 1999). In a survey of nonmigratory European butterflies, Parmesan et al. (1999) documented not only many extensions of northerly range limits but many range shifts, with the entire species range shifting poleward. An analysis of temperate-zone dragonflies in both hemispheres would be of interest to determine whether such shifts are occurring in this group.

References

Barber, B. & V. Elia, 1994. *Tholymis citrina*: a recent record from Florida and an historical record from Texas. Argia 5(4): 10-11.

Behrstock, R. A., 2000. New records of Neotropical odonates on the Upper Texas Coast with comments on recent temperature increases. Argia 12(1): 8-11.

Boomsma, T. & S.W. Dunkle, 1996. Odonata of Belize. Odonatologica 25: 17-29.

Daigle, J.J., 1997. Snowbirds sighted in the sunny Everglades! Argia 9(2): 13-14.

Daigle, J.J. & R.P. Rutter, 1984. New county records for *Crocothemis servilia* (Dru.) from Florida, United States. Notulae Odonatologicae 2: 63.

Davies, D.A.L., 1985. Infiltration by unwelcome strangers. Notulae Odonatologicae. 2: 99.

De Marmels, J., 1984. The genus *Nehalennia* Selys, its species and their phylogenetic relationships (Zygoptera: Coenagrionidae). Odonatologica 13: 501-527.

Donnelly, N., 1995. *Orthemis ferruginea* - an adventure in Caribbean biogeography. Argia 7(4): 9-12.

Donnelly, T.W., 1967. The discovery of *Chrysobasis* in Central America, with the description of a new species (Odonata: Coenagrionidae). Florida Entomologist 50: 47-52.

Dunkle, S.W., 1985. The taxonomy of the *Libellula vibrans* group (Odonata: Libellulidae). Transactions of the American Entomological Society 111: 399-405.

Dunkle, S.W., 1989. Dragonflies of the Florida Peninsula, Bermuda and the Bahamas. Scientific Publishers, Gainesville, Florida.

Dunkle, S.W., 1990. Damselflies of Florida, Bermuda and the Bahamas. Scientific Publishers, Gainesville, Florida.

Dunkle, S.W., 1992. Distribution of dragonflies and damselflies (Odonata) in Florida. Bulletin of American Odonatology 1: 29-50.

González Soriano, E. & R. Novelo Gutiérrez, 1996. Odonata. In: Llorente Bousquets, J., A.N. García Aldrete & E. González Soriano (eds) "Biodiversidad, taxonomía y biogeografía de artrópodos de Mexico: hacia una síntesis de su conocimiento". Universidad Nacional Autónoma de México, pp. 147-167.

Lee, D.S., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister & J.R. Stauffer, Jr., 1980. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History, Raleigh, North Carolina.

National Climatic Data Center, 2000; http://www.ncdc.noaa.gov/ol/climate/research/2000/win/win00.html; 13 March 2000.

Parmesan, C., N. Ryrholm, C. Stefanescu, J.K. Hill, C.D. Thomas, H. Descimon, B. Huntley, L. Kaila, J. Kullberg, T. Tammaru, W.J. Tennent, J.A. Thomas & M. Warren, 1999. Poleward shifts in geographical ranges of butterfly species associated with regional warming. Nature 399: 579-583.

Paulson, D.R., 1973. Temporal isolation in two species of dragonflies, *Epitheca sepia* (Gloyd, 1933) and *E. stella* (Williamson, 1911) (Anisoptera: Corduliidae). Odonatologica 2: 115-119.

Paulson, D.R., 1978. Additional record of *Crocothemis servilia* (Drury) from Florida (Anisoptera: Libellulidae). Notulae Odonatologicae 1: 29-30.

Paulson, D.R., 1982. Odonata. In: Hurlbert, S.H. & A. Villalobos-Figueroa (eds) "Aquatic Biota of Mexico, Central America and the West Indies". San Diego State University, San Diego, pp. 249-277

Paulson, D.R., 1999. Dragonflies (Odonata: Anisoptera) of south Florida. Slater Museum of Natural History, Occasional Paper 57.

Soltesz, K., 1992. An invasion of *Tramea calverti* on the northeast coast. Argia 4(3): 9-10.

Sprandel, G., 1996. Dragonfly occurrence on a north Florida pond, with notes on monitoring techniques. Argia 8(2): 26-29.

Westfall, M.J., Jr. & M.L. May, 1996. Damselflies of North America. Scientific Publishers, Gainesville.

Postscript

A publication just received from Geraldo Ihssen (Ihssen, G., E. Kappes & W. Kappes, 1997. Florida - Naturkundliche Reisenotizen 25. Dez. 1988 bis 6. Jan. 1989; Ihssen, G., 1997. Naturkundliche Reisenotizen aus Florida vom 9. bis 23. März 1991. Naturkundliche Reiseberichte 9: 1-62.) contains some records of interest in the context of this paper: *Chrysobasis lucifer*, one freshly emerged male collected in the Fakahatchee Strand, Collier County, 15 March 1991, indicates an earlier presence of this species in south Florida, in the same area where I found it, and adds it to the list of established species; *Tramea calverti*, one collected of 3-5 seen near Clewiston, Hendry County, 3 January 1989, indicates an earlier presence of this tropical species in south Florida; more extreme flight dates were listed for *Nasiaeschna pentacantha* (28 Dec 1988), *Epitheca stella* (1 Jan 1989), and *Libellula needhami* (4 Jan 1989).